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Mutschler, Max M.

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Keeping Space Safe

Towards a long-term strategy to arms control in space

Max M. Mutschler

Member of Leibniz Association

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Correspondence to:
PRIF · Baseler Str. 27-31 · 60329 Frankfurt am Main, Germany
Phone: +49(0)69 95 91 04-0 · Fax: +49(0)69 55 84 81
E-Mail: max.mutschler@uni-tuebingen.de
Website: www.prif.org

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Summary

When in 2007, China shot down an old weather satellite of its own this was the first test of an anti-satellite weapon since the 1980s. Many observers saw this as a reaction to an increasing investment of the United States in advanced technology for the "control" of space and warned of an arms race in space. Such an arms race would indeed have negative consequences for space safety and for the security of all space-faring nations. An exchange of violence in space would strongly restrain the usability of space and it could escalate to war on earth. But even below the threshold of a space war, space debris resulting from space weapon testing, could severely affect space safety. Currently, there are more than 21,000 pieces of trackable space debris in orbit that endanger other space objects such as satellites. Further testing of anti-satellite weapons would increase this number significantly. Keeping in mind that a lot of money is earned with space applications – the global revenue of the space industry in 2009 amounted to $261.61 billion – an arms race in space would have negative economic consequences, too.

Then how can we keep space safe? This is the central question, this report wants to answer. One recent initiative in this regard is the EU proposal to make the major space-faring states agree on a Code of Conduct for behavior in space. While the establishment of "rules of the road" for space would be a first step into the right direction, it does not ban space weapons and hence cannot prevent an arms race in space. This report argues that the establishment of an international arms control regime for space would be a better instrument to keep space safe and that the EU should therefore combine its Code of Conduct approach with an initiative to establish such a regime. Of course, an arms control regime for space cannot be established overnight. This report outlines a long-term strategy that maps out the central problems that must be solved to reach arms control in space. In order to do so, it draws on theoretical considerations on the establishment of international regimes.

The finding of this analysis is that in order to be able to agree on arms control in space, states must solve two classical problems of international cooperation, namely cheating and the unequal distribution of gains. This is possible, though, by drawing upon classical solutions to these problems, namely verification and issue-linkage. A first problem that prevents states from agreeing to arms control in space is the fear that other states would not stick to their commitment. This fear is reflected in the American concern for effective verification and, indeed, drawing up mechanisms for verification must be part of any arms control agreement for space. This is possible, though. Although not every action that could lead to the development of space weapons can be verified, testing space weapons under real conditions can. Since space weapons cannot be developed overnight, states can make use of a strategy of reciprocity, a kind of space weapons testing tit-for-tat. A second problem results from the fact that states tend to cooperate only, if the gains from this cooperation are distributed equally. This is not easy in the case of space weapons where the U.S. clearly has the technological lead. However, a general ban of space weapons provides for a compromise between the U.S. – that chiefly would benefit from a ban on ground-based anti-satellite weapons – and Russia and China who mainly seek to restrict the placement of more sophisticated weapons in orbit.

However, before these problems can be tackled, the major space-faring states have to "learn" that due to the interdependent character of space, unilateral strategies, i.e. developing space weapons, do not further their security. By drawing a parallel between the case of space weapons and nuclear arms control during the Cold War, this report argues that the emergence of a transnational epistemic community of space experts from the major space-faring states that produces consensual knowledge on the dangers of warfare in space would be an important step to foster learning in space. The EU could facilitate such a process of knowledge building by initiating a series of conferences among scientists from the major space-faring nations on the dangers of war in space.

Contents

1. Introduction

When the topic of "space" appears in the media, it is mostly in the form of another success story of space exploration.[1] However, there is also a "dark side" of human space exploration: the danger of the weaponization of space. From the start of the space age, the exploration of space was linked with politics on earth. Against the background of the Cold War, space emerged as another area to carry out the rivalry between the superpowers, and both the Soviet Union and the United States saw their space programs as a means to demonstrate the superiority of their social system. Yet beside these goals, both superpowers sought more concrete and direct military benefits from space, too. Whereas Sputnik in 1957 carried only a simple short-wave radio transmitter that allowed it to send its signals down to earth, the next generation of satellites was used for the purpose of reconnaissance. The U.S. reconnaissance satellite programs became operational in 1960-61 and the Soviet counterpart probably in 1963. It seems to be cynical but it is correct to ascribe these systems certain stabilizing effects on the international arms dynamic. First, they supplied the two opponents with credible information on the force level of the other side for the first time and thereby corrected unrealistic scenarios of missile or bomber "gaps." Second, they were helpful in the field of arms control. The insistence of the US on on-site inspections and the Soviet refusal of this instrument blocked arms control negotiations until the mid-1960s; until reconnaissance satellites provided for non-intrusive, so-called "national technical means of verification."[2]

Today, satellites are used not only for reconnaissance but for a variety of other functions, most of which can be put to a civilian and military purpose (dual-use): communication, meteorology, geodesy, and navigation. The Global Positioning System (GPS) for example was developed by the US military as a navigation aid and is still under military management. It is used to perform several important military tasks such as the navigation for troops and vehicles (on the ground and in the air), mission planning, and the guidance of precision munitions. When referring to these uses of satellites, one often speaks of the "militarization" of space but not its "weaponization" since these systems do not function as weapons themselves but are used to enhance weapons and military systems on earth. Sheehan (2007: 91) speaks of "space as a military force multiplier." Thus, one can see space as being militarized already since the early days of the space age, but it is not weaponized. One might want to add: not *yet*, since there are some alarming developments that indicate that the time of space as a "sanctuary," free from the terrestrial arms dynamics, might come to an end. Whereas both superpowers during the Cold War (successfully) tested weapons to shoot down satellites, so-called anti-satellite (ASAT) weapons, they refrained from a full development and deployment of these systems since they both valued the secure access to space as an important means to increase their

1 I am grateful to Kelly Neudorfer, Thomas Nielebock, Matthias Dembinski, and the people from PRIF who commented on earlier versions of this report.

2 Reconnaissance satellites enabled the monitoring of the deployment of missile silos in order to determine whether the limits under the SALT agreements are not violated; see Steinberg (1982: 379-381).

military strength and to stabilize their rivalry.[3] However, with its major rival in space gone and the importance of space for its military increasing, the U.S. started to think about the weaponization of space as both a means to project force down to earth and in order to protect its space infrastructure. Especially after 2001, the United States started to include the idea of "space control" – which means among other things to be able to deny access to space to other countries – into its space doctrine. For obvious reasons, this was not well taken by other space-faring countries, in particular by Russia and China, and many observers have warned against an arms race in space. These fears were nourished when, in January 2007, China successfully shot down an aging weather satellite of its own.

These recent events prompt the question: how can we keep space safe? This report gives an overview of this debate but it also takes up a stance on it. I argue that the establishment of an international arms control regime for space would be the best instrument to do so. Of course, such a regime cannot be established overnight. The fact that all attempts of conventional arms control in space were unsuccessful so far testifies to this. Consequently, this report outlines a long-term strategy that maps out the central problems that must be overcome in order to arrive at arms control in space. I make my argument in three steps. First, I depict where we are with regard to the weaponization of space. Second, I show where we should end up. And third, I consider how we could arrive at this point. I devote one chapter to each step. In chapter two, I analyze the danger of an arms race in outer space in more detail, drawing on a basic description of space weapons technology and an overview of doctrinal changes and events related to space security. In chapter three, I argue that arms control in space would be a reasonable strategy in order to avoid such an arms race. Arms control in the form of a legally binding treaty would be the best option. Non-binding "rules of the road" and confidence building measures as they are currently discussed should not be seen as a substitute for formal arms control, but rather as part of a long-term strategy to achieve arms control in space. How such a long-term strategy could look is the topic of chapter four. In this chapter, I draw on insights of three different approaches to the analysis of international regimes in order to identify the central obstacles that have inhibited the establishment of an international regime of arms control in space so far. The finding of this analysis is that in order to be able to agree to arms control in space, states must overcome two classical problems of international cooperation, namely cheating and the unequal distribution of gains from cooperation. Doing this is possible, though, by drawing upon classical solutions to these classical problems, namely verification and issue-linkage. However, before these problems can be tackled, the major space-faring states have to "learn" that due to the interdependent character of space, unilateral strategies, i.e. developing space weapons, do not further their security. By drawing a parallel between the case of space weapons and nuclear arms control during the Cold War, I argue that the emergence of a transnational epistemic community of space experts from the major space-faring states that produce

3 On the history of strategic restraint between the United States and the Soviet Union see Moltz (2008: 69-227).

consensual knowledge on the dangers of warfare in space would be an important step to foster learning in space.

2. The danger of an arms race in space

In this chapter, I analyze the danger of an arms race in space. I start with a short overview of the various categories of space weapons and their respective technologies. After this, I present an overview of the positions of the major players, the U.S., Russia, and China, with regard to the weaponization of space and conclude with three central arguments as to why an arms race in space should better be avoided.

2.1 Categories of space weapons

The definition of the term "space weapon" is already highly contested, and one can even argue that a definition of space weapons does not make sense because it would have to include a broad range of technologies used in space that have a dual-use character. Consider, for example, that a maneuverable satellite can be used for a range of absolutely civilian purposes, but it can also be used to hit another satellite, thereby damaging or destroying it. In order to avoid this problem, I follow a definition of space weapons that does not focus on strict technological demarcation but instead with intentions – a kind of "general purpose criterion" as it is used in the case of chemical weapons where one faces similar problems regarding the dual-use nature of many chemicals. According to this approach, a space weapon is any device (whether land-, sea-, air-, or space-based) purposely designed to damage or destroy an object in orbit or any space-based device designed to attack targets on earth.[4] In this chapter I make an attempt to categorize these weapons according to the geographic aspects of their effective direction and to their mode of operation.[5] According to geographic aspects, space weapons can either act from *earth to space*, from *space to space*, or from *space to earth*. Possible modes of operation would be *kinetic energy*, *directed energy*, and *nuclear explosion*. I start the discussion of space weapons with ASAT weapons. These weapons can either fall into the category of *earth to space* or *space to space*. After this, I discuss weapons that would be placed in space and project force down to earth.

Satellites are intrinsically vulnerable. They move at very high speed so that every collision with an object, even a very small one, can be disastrous. Besides, there is no place to hide in space. Once in orbit, the motion of a satellite is predictable.[6] It therefore comes

4 On such an approach see Moltz (2008, 42-43) and Grego/Wright (2010: 7, 20).

5 The subsequent description of space weapons is based on Dickow (2008: 109-111), Neuneck/Rothkirch (2005: 369–73), Neuneck/Rothkirch (2006: 26–32), Wright/Grego/Gronlund (2005), Preston (2002) and von Kries/Schmidt-Tedd/Schrogl (2002: 253-256).

6 This does not, however, mean that there are no measures to protect satellites and make them less vulnerable. Hardening can protect satellite components from being damaged by kinetic or directed energy. Special shields or resistant paints can offer some protection against electromagnetic pulses. Besides that,

as no surprise that there are a number of techniques to attack satellites. A nuclear explosion at an altitude of several hundred kilometers would produce a very powerful electromagnetic pulse that could probably destroy all unshielded satellites within sight in low earth orbit. In addition, the nuclear explosion would create persistent radiation in low earth orbit that would slowly damage unshielded satellites for many years to come. It would be rather easy for states with the respective technological options to equip an intermediate-range missile with a nuclear warhead and launch it into space (Neuneck/Rothkirch 2005: 370-371). The Anti-Ballistic-Missile (ABM) system that the Soviet Union deployed around Moscow in the 1960s had an inherent ASAT capability. The missiles were nuclear-tipped Intercontinental Ballistic Missiles (ICBMs) which meant that they were able to destroy space systems in the vicinity of their detonation (Webb 2009: 28). ICBMs that are fired from earth to earth but on their way pass through space are generally not considered to be space weapons.

Directed energy weapons could use the energy of lasers or microwaves to dazzle, blind, or destroy satellites. Lasers can emit large amounts of energy in a narrow beam. This enables the direction of energy towards a certain target with the speed of light. This laser technique can be used to interfere with a satellite's optical sensor by swamping it with light that is brighter than the light the satellite tries to image. Remote sensing satellites would be attractive targets for this so called "dazzling." If the laser light has sufficiently high intensity, it can even permanently damage the optical sensors of imaging satellites. The high intensity of the directed energy can cause the material of the sensor to melt, thus partially blinding the satellite. Laser weapons could be used to damage or destroy satellites, too. Here the laser is not used to dazzle or blind the optics of a satellite but to heat up the entire satellite in order to disrupt its thermal balance long enough to damage its components. This kind of attack needs a much stronger laser than attempts at dazzling or blinding. In consequence, such attacks would be restricted to technically advanced countries. Laser weapons can be conceived as either earth-to-space or space-to-space weapons. Other directed energy weapons could be based on high-powered microwaves. Microwaves are electromagnetic waves with wavelengths much longer than visible light but shorter than radio waves. Microwave radiation at high intensities can disorder the electronics of a satellite, hampering its function for some time or even damaging the electronics permanently if the microwaves are strong enough. In contrast to lasers, high power microwave weapons are not well suited to be used from earth since the beams of microwaves would be obstructed by the atmosphere. Thus it would make more sense to place such weapons in space (on a satellite) or to use a missile to launch them into space. However, the effectiveness of these weapons is highly uncertain – high power microwave technology is still maturing – and satellite electronics can be hardened against modest microwave attacks without great costs.

Kinetic energy is the energy in the motion of an object. In a successful kinetic energy attack, the damage or destruction of one object, a satellite for example, stems from the

of course, is the possibility to increase the capability of satellite maneuvering, enabling the evasion of an attack; and the build-up of redundancy, meaning that one always has some spare satellites in orbit that can replace damaged or destroyed ones.

high-speed collision with another object. A projectile is fired at a target – and destroys or damages the target by the sheer energy of its impact. This is called "hit-to-kill" technology. The existing ASAT technology makes use of this technique (Neuneck/Rothkirch 2005: 372). Kinetic energy ASATs can be earth-to-space or space-to-space weapons. Attacks with ground-based kinetic energy weapons (earth-to-space) are called direct-ascent attacks because the attacking object is launched directly from earth. A homing interceptor is launched on a missile that carries it above the atmosphere and releases it towards the satellite. The interceptor uses its thrusters to maneuver towards the target and hit it. There are some difficulties to launching an object directly to geosynchronous altitudes.[7] Accordingly, direct-ascent ASATS would probably be used against satellites in low earth orbit only. The technical requirements to develop such a weapon are the capability to acquire short range missiles and simple homing technology. According to Wright and colleagues (2005: 136): "Any space-faring country should be able to develop such an interceptor." An even easier way to damage or destroy a satellite would be the use of so called "space shrapnel": a cloud of pellets is simply launched into the path of an orbiting satellite. This is a technique available to all states with any sort of space launch capability.

Conceivable are also space-to-space ASAT systems. Such ASATs would be placed in orbit prior to the attack. Either shortly before the attack, such as the co-orbital ASAT developed by the Soviet Union, or well before usage. In this latter case one often speaks of "space mines." For the damage or destruction of satellites, space-based ASATs could use the same technologies as direct-ascent ASATs: homing interceptors or clouds of pellets. If such an ASAT has sufficient propellant, it would be well suited to attacking a satellite in geostationary orbit. So-called micro-satellites could be used as space mines, too. In a number of countries, significant work is being done on these small satellites. They are not in themselves weapons and are rather intended to be used for peaceful purposes; satellite refueling, for example. However, they are hard to detect and, if equipped with maneuvering capability and an explosive payload, they can act as space mines, approaching other satellites and damaging or destroying them by the impact of the explosion. They are cheaper than major communications or observation satellites. They represent an immense asymmetric threat to vulnerable space assets. This makes them attractive weapons for nations that want to build a deterrent against larger space powers (Hilborne 2007: 178-179).

The weapon systems discussed so far could all be used in order to establish space control, i.e. the capacity to deny an adversary the use of space. Besides those space weapons that aim at space control, there are also plans to use space-based weapons for the application of force against targets on earth (*space to earth* weapons). These weapons would allow attacking any point on earth at rather short notice. Satellites could carry a variety of conventional weapons: high explosives or kinetic energy weapons that would use the energy from their speed to destroy targets on earth. Because of their very high velocity, it would be hard to defend against such weapons. Conceivable are for example 1-

7 For the physical details of launching into and maneuvering in space, see Wright et al. (2005: 49-61, 77-84).

m-long tungsten rods weighing about 100 kg that are hurled earthwards at speeds over 7,200 mph. This would create an impact equivalent to a small nuclear weapon. Such a weapon could be used especially against buried targets such as bunkers or missile silos. However, these weapons would have to overcome many problems in order to work. Traditional, terrestrial weapons provide a cheaper alternative to space-based weapons (Garwin 2003; Hilborne 2007; Wright/Grego/Gronlund 2005). Deploying laser weapons in space would be another possibility to make use of the unique characteristics for war fighting. Already under the presidency of Ronald Reagan, the United States considered placing lasers in orbits in order to make them available for missile defense within the framework of the Strategic Defense Initiative (SDI), which soon got the nickname "Star Wars."

2.2 The United States, Russia, China and space weapons

Both the United States and Soviet Union developed and tested dedicated anti-satellite weapons during the Cold War. Already in the early 1960s, the U.S. tested its first ASAT missiles. The test results, however, were not encouraging and the project was stopped in 1963 (Webb 2009: 28). The Soviet Union on its part began testing a co-orbital anti-satellite weapon in 1968. The idea was that a satellite packed with explosives would be placed in an orbit close to the target satellite and would then be steered into it. The first test series ended in 1971 and demonstrated that the Soviet Union possessed the capability to place these so-called "hunter-killer" satellites into space that could destroy other satellites. A second series of testing started in 1976 and was continued until in 1982 a moratorium on launching ASATs – as long as no other country does so – was declared (Sheehan 2007: 103; Webb 2009: 28). What we can see from this is that both superpowers valued space as a "sanctuary" that should remain free from war in order to guarantee its use for other purposes, particularly for reconnaissance and early warning.

The strongest attack on this concept came from the SDI plans of the Reagan administration. Under Reagan, the idea of space as the ultimate "high ground" found support. The idea of the Strategic Defense Initiative was the development of a comprehensive capability for ballistic missile defense which included the deployment of active defense-weapons in space using "exotic" technologies such as lasers and particle beams. A wide range of key technologies for kinetic as well as directed energy weapons were being researched (Mowthorpe 2004: 17–19). Among them was the new concept of space-based interceptors, called "Brilliant Pebbles," where thousands of single interceptors with their own surveillance capability would have been placed into orbit. In addition, the U.S. under Reagan started again to think about ASAT weapons and developed a system where a high-flying F-15 aircraft was armed with heat-seeking missiles that could target satellites. This system was successfully tested in 1984 (Sheehan 2007: 97-103). Further development of weapons that physically destroy satellites has been restricted by Congressional bans and the voluntary Russian moratoria on testing them. "In practice […] neither country had heavily prioritized its ASAT program and by the mid-1980s the two countries were observing an informal, but effective mutual moratorium on ASAT tests" (Sheehan 2007: 103). In terms of SDI, several technical setbacks as well as budgetary limitations imposed by Congress led to a severe downgrading of the program. Under the administration of Bush senior and particularly in light of the breakup of the Soviet empire, the whole SDI program was re-evaluated and finally reoriented towards the protection from more limited ballistic missile attacks. The new Global Protection Against Limited Strikes (GPALS) program also included the concept of space-based interceptors for its approach of a layered defense. However, due to shifted budgetary priorities, these concepts never got past the phase of research and development. In sum, one can say that although the idea of space as a "sanctuary" came under pressure several times, the threshold of weaponizing space was never crossed.

Since 2001, however, this pressure is increasing again. Moltz (2008: 259) characterizes the time after 2001 as a period that has fundamentally challenged space security. According to him, this is basically the result of the change of administration that, together with the new president George W. Bush, brought into office a group of neoconservative thinkers who, in line with the views of the Air Force, perceived U.S. space systems as vulnerable and concluded that the weaponization of space could be the solution to this problem. The appointment of Donald Rumsfeld as Secretary of Defense signaled support for policies to weaponize space. Until his appointment, Rumsfeld had chaired the Commission to Assess United States National Security Space Management and Organization, the so called "Space Commission" that was established by Congress in 1999 and issued its report in January 2001 (Commission to Assess United States National Security Space Management and Organization 2001). This report regarded the U.S. interests in space as a top priority of national security policy. It warned of what it called a "Space Pearl Harbor," an attack on U.S. space systems. In order to avoid such an attack, the United States, the report argued, must "develop the means both to deter and to defend against hostile acts in and from space" (Commission to Assess United States National Security Space Management and Organization 2001: 10). This view on space and security is also summarized by an Air Force document of 2003:

> "Space capabilities are integral to modern warfighting forces, providing critical surveillance and reconnaissance information, especially over areas of high risk or denied access for airborne platforms. They also provide weather and other earth observation data, global communications, precision position, navigation, and timing to troops on the ground, ships at sea, aircraft in flight, and weapons enroute to targets. […] The United States cannot effectively exploit space for joint warfighting in these ways if it does not have responsive, reliable, and assured access to space, which requires achieving and maintaining space superiority. […] space superiority consists of activities that enable us to use space for those activities without interference from adversaries and prevent adversaries from using space for the same purposes" (U.S. Air Force 2003: 60).

The idea of being able to "prevent adversaries from using space" made its way into the U.S. National Space Policy (White House 2006), released in October 2006. This document, as the space policies of former administrations, stressed the freedom of the United States to acquire data from space. However – and here it departed from earlier policies – it also postulated the right of the U.S. to "deny such freedom of action to adversaries" and to execute "space control." The development of technologies that could be used in order to accomplish space control is ongoing. The U.S. has a number of research programs on the use of laser technology that could be used against objects in space, for example the Mid-Infrared Advanced Chemical Laser (MIRACLE) or the High

Energy Laser (HEL). The development and testing of experimental micro-satellites that could be used against other satellites is ongoing, too. Prototype satellites with the capacity to maneuver in space and photograph space objects were tested in 2003 and 2005.[8] And although the U.S. is currently not very much in favor of kinetic-energy ASAT technology – because of the space debris it generates (see chapter 2.3) – some of the systems that are conceptualized in the framework of the US plans for Global Missile Defense (GMD) would possess an inherent ASAT capability.[9] These weapons that are intended to intercept long-range missiles could be much more effective against satellites since satellites travel on predictable orbits that can be determined precisely by tracking from ground facilities. This makes them an easy target.

Needless to say, this claim for space control by the U.S. did not meet the support of other space-faring nations. In particular, Russia and China did not like to see their access to space being conditional upon the goodwill of the United States. In September 2003, in the hope of stopping the U.S. drive toward the deployment of space weapons, the Russian President Vladimir Putin pledged at the United Nations that Russia will follow a unilateral no-first-deployment policy on offensive space weapons (Moltz 2008: 279-280). The other side of the coin is the threat that Russia would not accept the deployment of space weapons by another state without reaction. Dating back to the time of the Cold War, Russia possesses considerable technical know-how in the field of ASAT-weapons. Until now there are no signs that Russia is actively working on space weapons. However, since the technological knowledge is present, it should be possible to implement an ASAT program at rather short notice (Neuneck 2008a: 140). The following statement of the commander of Russia's space forces, Colonel General Vladimir Popovkin, made in 2007, makes this point very clear:

> "We do not want to fight in space, and we do not want to call the shots there either, but we will not permit any other country to do so."[10]

China already went one step further in showing that it is not willing to accept the U.S. dominance in space. In January 2007, China successfully tested an ASAT weapon. This was the first ASAT test in over twenty years. A ground-launched ballistic missile destroyed one of China's own weather satellites, producing a large amount of space debris (more than 900 trackable debris objects). There are hints about previous Chinese tests in

8 For more details on these and other space weapon programs in the U.S. see Webb (2009).

9 In 2004, the US fielded five ground-based missile defense interceptors at Fort Greely in central Alaska and three more in Vandenberg (California) as part of their so-called Ground-based Midcourse System. "If launched straight up, this interceptor could lift the kill vehicle to a height of roughly 6,000 kilometers. It could therefore reach satellites in low-earth orbit, which are typically at altitudes less than 1,200 km, but not satellites in geosynchronous (36,000 km) or semi-synchronous orbits (20,000 km)" according to Wright and Grego (2003). Under the second Bush administration, a sea-based missile defense system was developed, referred to as the Sea-based Midcourse Defense. The so called *Aegis-LEAP* system, which consists of a modified version of the anti-aircraft missile used on *Aegis* cruisers topped with a kill vehicle, reportedly has a burnout speed of 3 km/s. Fired vertically, the kill vehicle would be able to reach altitudes of 400 to 500 kilometers and attack satellites at those altitudes (Wright/Grego 2003).

10 Quoted from Moltz (2008: 299).

2005 and 2006, in which no satellites were destroyed (Webb 2009: 30).[11] China has an ambitious space program and at the latest since its ASAT test, its threats to develop space weapons should be taken seriously. And since China is not the only country with space ambitions, others are likely to follow. On the third of January 2010, the director-general of India's Defense Research and Development Organization, V.K. Saraswat, announced that India– as part of its ballistic missile defense program – had started to develop an exoatmospheric kill vehicle that could, if combined with a guiding laser that was also developed, be used as a weapon to attack satellites in low earth orbit (LEO). According to the director-general, the building blocks of the system should be ready between 2012 and 2014. Mr. Saraswat said, though, that a dedicated ASAT weapon will only be built "if and when the country needs it."[12]

2.3 Why an arms race in space should be avoided

So far, I have discussed the various developments that have increased the danger of an arms race in outer space. One might want to ask now: What is the problem with an arms race in space? Why do we need arms control? Ultimately, the aims of arms control in space are the same ones as the classical goals of arms control as they were pointed out by Thomas Schelling and Morton Halperin (1961) in their landmark writing on arms control: 1) reducing the risk of war, 2) reducing the cost of preparing for war, and 3) reducing damage should war occur. I will consider them in turn with regard to their relevance for space.

Arms control can help to avoid war inasmuch as it can help states to achieve or hold a situation of strategic stability. This means that neither side achieves a decisive breakthrough in the development of weapons that strongly increases the capability to strike first and/or that decreases the risk of a return attack (Schelling/Halperin 1961: 37-38). Such a situation that clearly favors the offense, increases the likelihood for the outbreak of war because each side has the incentive to strike first in order to pre-empt the first strike of the other side. In the words of Schelling/Halperin (1961: 11) "The pre-emptive advantage makes the suspicion of war a cause of war."[13] The deployment of weapons in space would create such a dangerous situation. Since satellites travel in predictable orbits around earth they are highly vulnerable to an attack and it is difficult to protect them against attacks (Grego/Wright 2010: 14). This means, once a state has the capability to put the space assets of another state at risk, it might be very attractive to use this as a threat in a time of political crisis. If the other side has space weapons, too, such a threat to its space assets might trigger a dangerous chain reaction, since it will be confronted with the options to either "use" or "lose" its space weapons. Even the loss of a satellite that was not caused by the use of ASATs could be interpreted as an attack (Grego/Wright 2010: 6). And to make things worse, such a shooting war is rather unlikely

11 For a detailed analysis of the Chinese ASAT test see Neuneck (2008b).

12 Space News, January 11, 2010.

13 See also Krell/Minkwitz/Schörnig (2004: 557-559).

to remain in space because the terrestrial infrastructure for the communication with space systems automatically becomes an attractive target, too. If one considers the potential for future political-military crises between Washington and Beijing (for example over Taiwan), one would not wish to worsen such a crisis by an ASAT-armed China that could take out U.S. satellites and a U.S. that consequently feels the need to pre-empt such a Chinese move (Swaine 2007).

Arms control can also help to avoid high costs that are usually the result of an arms race. Since economic resources are limited, there is always a question whether to allocate them to armament or some other fields. The reduction of this economic burden in order to invest the free resources in other activities is the oldest argument for disarmament and arms control (Bull 1961: 12-13). In the case of space weapons, this argument should be a very powerful one, since a lot of resources are needed to develop and deploy these high-tech weapons. To give only one example, according to David Wright and colleagues (2005: 99) it would cost roughly $40 billion to deploy a system of space-based interceptors for missile defense. These $40 billion are only the launch costs and do not include the money that has to be spent on the development and maintenance of such a system.

Finally, arms control can help to reduce the damage in case war should occur. A full scale space war would severely damage the usability of outer space. Already an arms race in space endangers the sustainable use of space because it would be accompanied by an increased testing of space weapons. Each destruction of an object in space results in a huge amount of small pieces of space debris that remain in orbit for a long time. The vacuum of space means that objects in space, once propelled, do not lose their speed unless they are low enough to be slowed down by atmospheric drag and over time fall back to earth. This means that pieces of space debris, depending on their altitude, can stay in orbit for decades or even centuries. There is already a considerable amount of such debris in space resulting from decades of space-flight, mainly consisting of parts of old spacecraft, non-functioning satellites, and remains of intended or unintended explosions in space (Neuneck/Rothkirch 2005: 375). Currently, there are more than 21,000 pieces of space debris that can be tracked by the U.S. Space Surveillance Network (SSN) (Grego/Wright 2010: 4). These pieces, even the smaller ones, endanger other objects in space. Should the testing of ASAT weapons be increased, there is the real danger of a chain reaction that has severe consequences for the use of space. The ASAT tests of the Soviet Union and the U.S. during the time of the Cold War left hundreds of pieces of traceable debris in space of which some are still out there today (Neuneck/Rothkirch 2005: 376-377).

In sum, there are a number of good arguments why an arms race in space should be avoided; it would cost a lot of money, decrease the safe use of space, and in the worst case provoke violence in space in case of a crisis with the potential of escalation into full scale war. The good news is that the respective technologies are not fully developed. This creates a chance for "preventive" arms control in space (Neuneck/Rothkirch 2006), meaning that dangerous technologies would be controlled already at an early phase, before the efforts that were invested in their development provide an argument in itself against any limits on the technology.[14] In the next chapter, I turn to the instrument of arms control as an instrument to avoid an arms race in space.

3. Arms control in space

3.1 Failed attempts for arms control in space

After the start of Sputnik in 1957, the General Assembly of the United Nations (UN) set up the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) in 1958 in order to develop space law. In consequence, treaties on conduct in space were concluded. The most important of these is the Outer Space Treaty (OST) of 1967. It declares that space is free of any claims by states and proclaims the "peaceful use" of outer space. A definition of "peaceful" however, is missing. Only the deployment of weapons of mass destruction – for example placing nuclear explosive devices into orbit – is banned.[15] In this regard the treaty, in article III, only commits parties to the treaty to "carry on activities in the exploration and use of outer space, including the Moon and other celestial bodies, in accordance with international law, including the Charter of the United Nations." This means that for a definition of "peaceful purpose" one has to take a look at the UN Charter. Article 2(4) of the Charter obliges states to refrain from the use of force. However, article 51 of the Charter clearly states the right of self-defense. This allows the interpretation of "peaceful" as "non-aggressive." It keeps the door open for the argument that it is legal to deploy conventional weapons in space if the deployment is intended not for aggressive use but only for self-defense (von Kries 1991: 337–9; Schrogl 2005: 69-70, 73). As a consequence of this unfinished business, since 1981, the UN General Assembly has annually reaffirmed a call to undertake the necessary steps for the prevention of an arms race in space. Several states proposed to deal with the issue of the militarization and weaponization of space in UNCOPUOS. However, the US rejected these proposals on the ground that UNCOPUOS had no disarmament mandate and referred the question to the Conference on Disarmament (CD) in Geneva. In 1985, the Ad Hoc Committee on the Prevention of an Arms Race in Outer Space (PAROS) was set up (Wolter 2006: 56-64).

Right from the start, the big split in the committee was between a majority of states that wanted to start actual negotiations on the banning of space weapons and the United States that rejected such proposals. The large majority held the opinion that the legal standards set up by the development of space law so far (especially the OST) could not by themselves prevent an arms race in space and therefore should be amended. The U.S., on

14 On the concept of preventive arms control ("Präventive/Vorbeugende Rüstungskontrolle") see Altmann (2008); Brauch et al. (1997); Neuneck/Mutz (2000); Petermann/Socher/Wennrich (1997).

15 In Article IV of the OST the parties agree "not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner."

the other side, insisted upon its position that there was no danger of an arms race in outer space and therefore new treaty stipulations on the use of space were needless. Thus, over the first ten years of its existence, PAROS was not able to agree on a negotiating mandate. Even worse, in 1995 the mandate of the committee (which had to be renewed annually) could no longer be extended, since the PAROS issue was linked with the establishment of other ad hoc committees, for example on the negotiation of a Fissile Material Cut-off Treaty (FMCT), and no agreement about the general work program of the CD could be found. As a result, no substantial talks on the question of PAROS took place in the CD since 1995 (Wolter 2006: 64-66). Especially China and Russia made efforts to start negotiations on banning space weapons. In June 2001, China delivered a working paper on a future "Treaty on the Prevention of the Weaponization of Outer Space" (Conference on Disarmament 2001). With this working paper, China substantiated the ideas first expressed in a rather vague working paper of February 2000. The proposed treaty would include the basic obligation "not to test, deploy or use in outer space any weapons, weapon systems or their components" as well as the obligation "not to test, deploy or use on land, in sea or atmosphere any weapons, weapon systems or their components that can be used for war-fighting in outer space" (Conference on Disarmament 2001: 3). This is a proposal for a comprehensive ban of any kind of space weapon, including weapons placed in space with the capacity to attack objects in space or on earth, as well as weapons that could be used from earth to attack objects in space.

In June 2002, China and Russia, together with some other delegations,[16] introduced a joint working paper on possible elements of a treaty preventing the deployment of weapons in space (Conference on Disarmament 2002). This paper basically builds upon the previous Chinese working paper. However, it is much more cautious regarding the banning of certain activities. The two major obligations are (Conference on Disarmament 2002: 3):

> "Not to place in orbit around the Earth any objects carrying any kinds of weapons, not to install such weapons on celestial bodies, or not to station such weapons in outer space in any other manner. Not to resort to the threat or use of force against outer space objects."

This has two major implications compared with the Chinese working paper of June 2001. First, it still bans the deployment of weapons in space but not their testing (Neuneck/Rothkirch 2005: 380). Second, the explicit ban is on the deployment of weapons in space but not any longer on the deployment of weapons on land, in sea or atmosphere that can be used against space objects. This means, for example, that ground- or sea-based missile defense interceptors would not be banned by such a treaty. A test of a ground-based ASAT system, as performed by China in 2007, would also be legal. This proposal was clearly rejected by the United States. In his statement on this joint working paper, Ambassador Eric M. Javits, Permanent Representative of the United States to the CD, made it clear that the U.S. did not agree with the position of China and Russia:[17]

16 The other delegations were: Vietnam, Indonesia, Belarus, Zimbabwe and the Syrian Arab Republic.

17 The US statement on the joint working paper is printed in the INESAP Information Bulletin No.20, August 2002: 38.

> "[…] the United States sees no need for new outer space arms control agreements and opposes the idea of negotiating a new outer space treaty. We believe the existing outer space regime is sufficient."

In the following years, Russia and China were eager to further their ideas on the creation of an international legal instrument for the prevention of an arms race in outer space. After various discussions of single aspects such as definitions of central concepts or the question of verification, in February 2008 they issued another working paper to the CD that presents a revised version of their earlier ideas and proposes a draft "Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects (PPWT)" (Conference on Disarmament 2008a). The central obligation as stated in Article II of the draft treaty reads as follows:

> "The States Parties undertake not to place in orbit around the Earth any objects carrying any kinds of weapons, not to install such weapons on celestial bodies and not to place such weapons in outer space in any other manner; not to resort to the threat or use of force against outer space objects; and not to assist or induce other States, groups of States or international organizations to participate in activities prohibited by this treaty."

An explanatory statement by Russia and China makes clear that their proposed PPWT "does not prohibit interceptors of ground-based, sea-based or air-based ABM systems […]" and "does not prohibit the development of ground-based, water-based, or air-based anti-satellite weapons systems […]" (Conference on Disarmament August 2009: 4). Instead, it focuses on a ban of space-based weapons and a ban on the "use of force against outer space objects." In other words, according to such a treaty it would be legal to develop and deploy earth-based ASAT weapons, but not to actually use them against objects in space. This was a point about which the United States was particularly concerned, since they feared such an agreement would allow any party to build up a breakout capability.[18] Other points of criticism of the U.S. were the lack of concrete provisions on verification mechanisms and the proposed establishment of an international executive organization that would be tasked with compliance matters. For the US it is unacceptable to delegate the final compliance/enforcement authority to an international organization other than the UN Security Council. Taken together, these points lead the United States to conclude that this draft of 2008 is "even more unacceptable" than the Chinese-Russian draft of 2002 (Conference on Disarmament 2008b: 8). Summing up, one can say that all proposals made for formal arms control in space were rejected by the United States and hence, the Conference on Disarmament did not make any progress on this matter.

18 This U.S. concern is expressed in a CD document by the following statement: "Since the draft Treaty only bans the placement of weapons in space (and thus indirectly prevents the testing of on-orbit weapons), a Party could build a breakout capability – consistent with the provisions of the Treaty – as the proposed draft Treaty would not ban the research, development, production, or storage of (orbital) anti-satellite systems, […]" Conference on Disarmament (2008a: 8).

3.2 Rules of the road for space?

The deadlock of the negotiations within the Conference on Disarmament on formal arms control in space led to a search for alternatives. Proposals were made that do not suggest formal agreements to ban certain weapons technologies but instead aim to set standards of behavior in space, so called "rules of the road." Rather than in the form of a formal treaty, these standards of appropriate behavior could take the form of an (only politically binding) code of conduct. In 2004 the Henry L. Stimson Center proposed a "Model Code of Conduct for the Prevention of Incidents and Dangerous Military Practices in Outer Space" (The Henry L. Stimson Center 2004). The main obligations as stated in this code of conduct are the avoidance of collisions and simulated attacks in space; creating special caution and safety areas around satellites; developing safer traffic management practices; prohibiting anti-satellite tests in space; providing reassurance through information exchanges, transparency and notification measures; and the adoption of more stringent space debris mitigation measures.[19] In 2006 and 2007, the Henry L. Stimson Center proposed more limited versions of the code of conduct that refrain from defining certain key concepts such as "space weapons" in order to make it easier to reach a consensus (The Henry L. Stimson Center 2007). The main obligations remain the same, though. A very important part of such a code of conduct would be a ban on the so called "harmful interference with satellites." Such "harmful interference" includes the destruction or damaging of satellites, and any temporary interference with the normal operation of the spacecraft. According to Black (2008), a code of conduct that includes a ban on the described methods of harmful interference has the advantage that states would not need to agree on a definition of space weapons and on modes to verify their non-existence. This idea of "rules of the road" is also reflected in a study of the International Academy of Astronautics (IAA) that promotes the concept of "space traffic management."

> "Space traffic management means the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from outer space to Earth free from physical or radio-frequency interference" (International Academy of Astronautics (IAA) 2006: 10).

The idea of a code of conduct was taken up by the European Union in December 2008 when the Council of the European Union approved a *Draft Code of Conduct For Outer Space Activities* (Council of the European Union December 2008) (hereafter referred to as CoC). It was preceded by internal discussion between EU member states as well as exchanges of views with the US, China, and Russia.[20] In September 2010, the Council of the European Union agreed on a revised draft of the CoC and requested the High Representative to pursue further consultations with third countries on the draft (Council of the European Union 2010). The centerpiece of the measures the subscribing states would agree on is to:

19 On this proposed code of conduct see as well Krepon/Heller (2004) and Krepon/Hitchens/Katz-Hyman (2007).

20 For more information on the background of the EU Draft Code of Conduct For Outer Space Activities, see Rathgeber, Remuss/Schrogl (2009) and Dickow (2009).

> "[…] refrain from any action which intends to bring about, directly or indirectly, damage or destruction of outer space objects unless such action is conducted to reduce the creation of outer space debris and/or is justified by the inherent right of individual or collective self-defense in accordance with the United Nations Charter or imperative safety considerations; […]" (Council of the European Union 2010: 7).

In other words, this is a ban of the harmful interference with outer space objects. Furthermore, the CoC would commit states to "refrain from the intentional destruction of any on-orbit space object or other activities which may generate long-lived space debris" (Council of the European Union 2010, 8). In addition, the CoC codifies particular confidence-building measures regarding the notification of outer space activities, the registration of space objects, information-sharing on space activities, and consultation. It further stipulates biennial meetings of subscribing states, as well as the establishment of a central point of contact and an outer space activities database. There are also a number of other proposals for transparency- and confidence-building measures (TCBMs) that are not directly connected with the idea of the CoC but which could be seen as useful supplements for such a code. An example would be unilateral no-first-use-declarations, a moratorium on the testing of space weapons, or the abdication of the use of missile defense for ASAT-purposes.[21]

One definite advantage of such a "rules of the road" approach is that it is likely to find the support of the United States under the Obama administration. Already in the policy papers of Obama's election campaign one could find a hint at a more cooperative approach towards space. One campaign document states: "Barack Obama opposes the stationing of weapons in space and the development of anti-satellite weapons" (Obama for America 2008). To deduce a complete change of U.S. space policy from this, however, would be premature. The new National Space Policy released by the Obama administration in June 2010 (White House 2010) does not speak of an intention of the U.S. to deny the freedom of action in space to other countries. Instead, it announces that the U.S. will engage in confidence-building measures in space and that the U.S. "will consider proposals and concepts for arms control measures if they are equitable, effectively verifiable, and enhance the national security of the United States and its allies." This is clearly a renunciation of the space policy of the Bush administration, which stated that the U.S. was not willing to sign any agreement that limited its freedom of action in space.[22] However, it is not very likely that this change of intent will translate directly into a U.S. support for arms control in space. A cautious approach that favors a non-legally binding code of conduct and some confidence-building measures is more likely (Black 2010; Foust 2010). This estimate is supported by a look at the remarks of Frank A. Rose, the Deputy Assistant Secretary at the Bureau of Verification, Compliance, and Implementation, when he outlined the new U.S. space policy at the Conference on Disarmament on July 13, 2010. In his address to the CD, Rose emphasized the importance his country attaches to international cooperation in space and that it is willing to develop

21 On TCBMs for space see for example Neuneck/Rothkirch (2006: 49–51), Hilborne (2007: 187-188), and Robinson (2010).

22 See U.S. Space Policy (2006).

transparency and confidence-building measures in order to promote the safe and responsible use of space. However, in a press briefing on the same day, he said that there was no proposal for a space arms control treaty that would meet the criteria of the U.S. (equitability, verifiability, and enhancing national security).

> "The U.S. position on the PPWT Treaty has not changed. We still see the document as a flawed document that is neither equitable nor effectively verifiable. That said […] the United States is very interested in working with Russia, China and other space-faring nations to promote concrete transparency and confidence-building measures that will provide for stability in space."[23]

Rose reaffirmed that one issue that is particularly worrisome for the U.S. about the PPWT is that it does not ban land-based, kinetic energy anti-satellite capabilities. Keeping this in mind, it indeed seems likely that the U.S. will focus its efforts on "rules of the road" for responsible behavior in space and on additional TCBMs. Such an approach seems to find support among at least some members of the U.S. military, too.[24] Accordingly, the unclassified summary of the National Security Space Strategy released in January 2011, acknowledges the "contested" nature of space and states that the U.S. is willing to support TCBMs and "norms of behavior for responsible space operations" (U.S. Department of Defense 2011: 5).

3.3 Arms control vs. rules of the road?

Which of the two approaches – arms control in form of a legally binding international treaty or "rules of the road" – is better suited to make space safe? I start with a discussion of the pros and cons of a "rules of the road" approach.[25] Clearly, agreeing upon a code of conduct for behavior in space is much easier than agreeing upon an arms control treaty. Most people would probably rather agree upon a voluntary commitment than upon a legally binding treaty because the consequences of violating the agreement are more severe in the latter case. If a state violates an international treaty it agreed upon, this has negative consequences for its reputation as a partner for international cooperation, which in turn will probably affect the chances for this state to be able to reap benefits from such cooperation in the future.[26] The violation of a code of conduct will perhaps have a

23 Press Conference by Deputy Assistant Secretary Fran A. Rose, July 13, Geneva. A transcript of the press conference as well as of Mr. Rose's speech at the CD can be found at http://geneva.usmission.gov (17.11.2010).

24 Air Force General Kevin P. Chilton on "rules of the road": "we should examine the potential utility of a code of conduct or 'rules of the road' for the space domain, thus providing a common understanding of acceptable behavior within a medium shared by all nations." Quoted from Moltz (2008: 299–300). This statement was made shortly before the congressional hearings on General Chilton's confirmation as the new commander of U.S. Strategic Command which he became in October 2007.

25 See also Dickow (2009) and Mutschler (2010).

26 In case one prefers an account that is based upon a "logic of appropriateness" rather than on a "logic of consequentiality," one might argue that a state which considers itself part of the international community of states for which the norm *pacta sunt servanda* ("agreements must be kept") holds, will not want to violate this norm because it would not be considered appropriate behavior for a member of that community. On both accounts, see Hasenclever/Mayer/Rittberger (2002: 35-36, 155-157, 163-165).

negative effect, too, but probably not to the same degree. Thus, there seem to be less severe consequences to fear if one should want to step back from a code of conduct, and hence such a code is easier to agree upon. A second point that is made in support of a code of conduct is that it avoids lengthy debates about definitions of the technologies that are to fall under the proscriptions. Admittedly, it will be a complicated and time consuming process to agree on a definition of "space weapon." Given the fact that even the definition "space" is disputed, there is certainly a point to this argument. However, as I have pointed out already at the beginning of chapter 2.1, the definition of space weapons that focuses on the purpose instead of the technology could help to overcome this problem.

The major arguments in favor of a "rules of the road" approach which I discussed above – its soft law character and its avoidance of a ban of space weapons – are, however, the major shortcomings of this approach, too. First, it is precisely because the costs of violating an international treaty can be considered higher than in the case of code of conduct, that it is more likely that states are willing to abide by the treaty. The damage that cheating does to your reputation is something you seriously want to consider before breaking the rules.[27] For the very same reason, the agreement to a treaty signals a stronger commitment to the respective rules. Which state would agree to a treaty it does not intend to keep? This could build much-needed trust between the parties. Second, an agreement that bans certain behavior – in this case the harmful interference with satellites – but does not restrict the means to do so can hardly be considered comprehensive. Under the Code of Conduct proposed by the EU, the development of space weapons could continue. The code prohibits the destruction of satellites but not the development of ASAT weapons[28] (or other space weapons such a space-based lasers for missile defense). This means that in times of crisis – when one might find it justified not to stick to rules – these weapons could be readily available. In addition, there is at least one other argument to be taken into account. The general tendency of the space policy of the Obama administration with its focus on international cooperation and its lack of claims for space control by the U.S. might go along with "rules of the road" rather well. We have, however, no reason to assume that there will never again be any change of U.S. space policy in the future. Nor do we have reason to believe that there will not be any changes in the internal constellations of Russia or China (not to mention any future nation with space ambitions) that are followed by a more aggressive posture with regard to space. In such situations it is harder for the new actors to change the established policies if those are "enshrined" in the principles, norms, and rules of a formal international regime. Harald Müller (1993) has shown in an analysis of three different security regimes that security regimes do not easily fall victim to such recalculations of national interests. The rules embedded in international treaties play a central role. Treaty obligations are converted into domestic

27 As Müller 1993, 385 has put it: "The norm *pacta sunt servanda* puts a heavy burden on those who want to breach legally fixed regimes."

28 Although one must concede that at least the testing of certain ASAT technologies (those that generate long-lived space debris) would be restricted by the Code of Conduct measures on space debris control and mitigation.

legislation. This means that the breakout from a treaty is not only a matter of the position of the executive but also of an internal debate and thus faces a much higher hurdle. Within these debates, the norms and rules of the treaties provide a focus for the supporters of arms control and play an important role as systems of reference for the debate.[29] From this perspective, it would be much harder for a future U.S. administration to return to an offensive posture in space if there was a treaty banning the development of space weapons.

This is not to say that a "rules of the road" approach as taken by the EU Code of Conduct does not have its merits. Its pragmatic approach makes it a suitable starting point for the discussions among states and if it would find the support of the U.S., Russia, and China, this would be an important step to increasing space security. However, the conclusion of the arguments presented here is that a formal treaty that bans the development of space weapons is better suited to keeping space safe in the long term.

4. Towards a long-term strategy to arms control in space

Up to this point, I argued that arms control would be helpful to keep space safe. In this chapter, I outline a strategy for how to achieve arms control in space by identifying the problems that have frustrated the previous attempts at arms control in space. For the identification of these problems I make use of various approaches to explain the emergence of international regimes.[30] If there is a demand for an international regime and still none of these components is present, Dimitrov and colleagues (2007) speak of a "non-regime." Accordingly, since I seek an explanation for the non-regime of arms control in space, I draw on theories of international regimes which I categorize according to three key variables of International Relations: interests, power, and knowledge.[31] On the basis of this analysis, I point at ways how the problems can be overcome.

4.1 Arms control in space and interests

According to neoliberal institutionalism (Keohane 1989; Keohane 1984), one of the most prominent theories of international cooperation, the *interests* of states – conceptualized as their preferences over outcomes that maximize their utility – determine their behavior and thereby their interaction on the international levels. International cooperation is often necessary for states to achieve their interests. Cooperation, however, is not easy to

29 "[…] the sheer existence of a regime puts an 'extra' burden of proof on regime opponents because in discourses about proper behaviour of states and other regime actors, the regime structure serves automatically as frame of reference" Müller (1993: 383).

30 International regimes can be defined as "sets of implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge in a given area of international relations" Krasner (1983: 186).

31 Hasenclever, Mayer, and Rittberger (2002) divide theories of international regimes into interest-based, power-based, and knowledge-based theories.

achieve due to a number of collective action problems such as the famous prisoner's dilemma where the collective optimum can only be reached by cooperation between the players but where the fear of cheating leads both players to choose the non-cooperative strategy that ensures they avoid the worst-case scenario.[32] In the literature, it is quite common to analyze the decisions of states to arm or not to arm as a prisoner's dilemma (Müller/Schörnig 2006: 40-47; Stein 1983: 312-313). The collective optimum would be no armament or at least the control of armament on both sides. However, there is the temptation to acquire an advantage by choosing defection (arming). The insecurity about the motives of the other state(s) makes all sides choose defection and arming becomes the dominant strategy.

The basic logic of the prisoner's dilemma holds for arms control in space, too (Luithardt 2009). All space-faring nations should have a general interest in the continued usability of space, as space-based communication, navigation and meteorology are increasingly important factors for the modern economies of the 21st century. Satellites have become an important part of the global infrastructure (Neuneck 2008a: 130; Neuneck/Rothkirch 2005: 367-368). Nearly 1,000 satellites orbit in space and provide various benefits to the people down on earth. They are useful for a broad spectrum of activities such as: travel and entertainment; energy, resource, and environmental management; governance, education, and infrastructure; retail, finance, and corporate services; transportation, logistics, and manufacturing; homeland security, defense and intelligence; science, biotechnology, and health care.[33] For example, satellites are intensively used for communication purposes such as satellite telephones, satellite television, or satellite radio. Many applications make use of navigation satellites systems such as the GPS. Satellite navigation profoundly improved the effectiveness of road, sea and air travel. It is estimated that by 2020, over 450 million cars worldwide will be equipped with on-board satellite navigation systems (European Space Policy Institute 2009). A lot of money can be made by the provision of these services. According to the Space Foundation (2010), the global revenue of the space industry in 2009 amounted to $261.61 billion.

Space is valuable not only for highly developed countries, though. Space can be important for developing and emerging market countries (such as China), too. These countries seek space capabilities for the very same reasons as developed countries: the expected positive effects on the development of an industrialized society (Johnson-Freese 2007: 202-203). There are good arguments for drawing a parallel between the Chinese decision for manned spaceflight and the US decision for the Apollo program. Both programs aimed at increasing domestic pride, international prestige, development of dual-use technology, and benefits for science and engineering as well as the creation of skilled jobs (Handberg 2007; Johnson-Freese 2007: 204). In sum, a decline of space sustainability would negatively affect the interests of nearly all states but especially those

32 On the original concept of the prisoner's dilemma see Luce and Raiffa (1965).

33 These are the categories for the listing of space services and products gathered by the Space Report of the Space Foundation 2010.

of the major space-faring countries. This means that a sustainable use of space is very high on the preference order of those states. An arms race in space would endanger the sustainable use of space because it would be accompanied by increased testing of space weapons, which in turn would generate a lot of space debris[34] and hence endanger the prospects of absolute gains from space (Hansel 2010: 94-95). The Chinese ASAT test in January 2007, for example, generated more than 2,000 pieces of wreckage larger than 10 centimeters that will remain in space for decades and endanger the orbits of many satellites (Neuneck 2008a, 136). Where is the collective action problem? Shouldn't we expect states to abstain from the development of space weapons because of pure self-interest, then? The problem is that in questions of armament, security considerations come into play. In an anarchical international system, a state has the incentive to increase its security by increasing its armament. And each state must fear that if it forgoes this option, other states will develop the weapons and gain a powerful instrument to threaten other states. These considerations lead risk-averse states to continue with the development of weapons instead of concluding an agreement on arms control.[35]

Fortunately, neoliberal institutionalism did not only point out the problem of achieving collective action in international politics, it gave some hints on the solutions, too. International regimes are viewed as a functional solution to the cheating problem of the prisoner's dilemma because they can reduce this risk of defection by clearly defining cooperation and by setting up monitoring agreements. These agreements make information available on the compliance of the cooperation partners, lowering the risk of cooperation. Each is informed about the non-cooperation of the other(s) and can change its own strategy, and the probability of being identified as a cheater reduces the expected utility of cheating. However, it is important that the "game" is not played as a one-shot-game and that the so-called "shadow of the future" enables states to follow a strategy of reciprocity. This means that a state chooses to reward cooperation of the other side with cooperation in the future and accordingly to punish current defection with defection in the future.[36]

Cooperation on arms control in space is possible with the help of such a strategy of reciprocity. The process of research and development of space weapons takes time, newly developed components must be tested, and the most important tests – those which are conducted under conditions close to reality – can be verified by other states. Space is large, but it is also a very transparent medium. This allows for remote tracking, surveillance and observation with a number of means, such as optical, infrared, radar, electronic, or electromagnetic technologies (Hagen/Scheffran 2003). I follow the arguments of Hagen and Scheffran (2003) and show how potential ASAT weapons could be verified. Any maneuverable spacecraft can be used for ASAT purposes just by steering

34 On space debris see chapter 2.3 of this report.

35 For Luithardt (2009), this explains why we do not have arms control in space. In the reminder of this chapter I show, however, that we have to take additional information into account that makes the non-regime more puzzling for this theory.

36 This strategy is called "tit for tat" see Axelrod (1984); Axelrod and Keohane (1986).

it into another space object and destroying it by the sheer impact; or at least pushing it off its orbit. Alternatively, one can imagine dedicated space mines that attempt to destroy a satellite by releasing explosives, shrapnel or making use of electronic jamming or laser blinding devices. In any case, this kind of spacecraft would need to approach its target. Such an attempt could be detected with radar and/or optical systems. Similarly, any use or testing of a ground-based conventional missile that is used for ASAT purposes, such as the systems tested by the Soviet Union, the U.S. and only recently, China, can easily be observed with existing systems. The launch can be detected by infrared sensors on early warning satellites while tracking radars and telescopes can be used to follow the maneuver. The fact that the U.S. clearly noticed the Chinese ASAT test in 2007 testifies to this. The testing of laser weapons, another means to either attack objects in space and/or from space, can be verified, too. Any realistic test – on the ground, in the air or in space – could be detected. Space-based infrared sensors can note the heat dissipation resulting from high-energy lasers. In addition, such lasers are very large so that they could be detected by reconnaissance satellites. If they were deployed in space, existing space tracking systems could easily detect them.

In sum, a space weapon ban would not be completely verifiable if it is seen as necessary to verify the complete non-existence of such weapons. This is not possible because of the option to turn every maneuverable spacecraft into an ASAT weapon (here, skeptics of arms control in space are correct). What is possible, though, is the verification of the testing of various kinds of space weapons. Since the testing of new weapons is an essential part in the process of weapon development, an agreement of preventive arms control in space is mainly verifiable. These verification procedures could be even more robust if states could agree on inspections of the launch-sites and/or factories of the final assembly of relevant spacecraft (Neuneck/Rothkirch 2005: 381).[37] A worst-case scenario where one state forgoes the development of space weapons and in consequence finds itself threatened by another one with these weapons can be avoided. It takes time to develop the respective technologies and chances are high that, even if one does not agree on very intrusive verification procedures, certain steps in the process can be verified. Should one party observe cheating by another party of the agreement, a state still has time to react with its own development and testing of space weapons. A kind of space-weapon testing tit-for-tat is possible. Consequently, the establishment of an international regime that bans the development, testing, and deployment of space weapons and that draws up respective verification procedures is the functional solution that helps to overcome the collective-action problem.

4.2 Arms control in space and power

The interest-focused approach presented in the chapter above does not suffice as an explanation of the problems that are connected with the establishment of arms control in

37 For a detailed discussion of in-factory and launch-site verification regarding space weapons, see Cleminson/Gasparini Alves (1992: 187-194).

space, however. In fact, if there is a common interest in the sustainability of space and the establishment of an international regime of arms control in space would facilitate cooperation by enabling reciprocal strategies of cooperation, it is rather puzzling that there is no such regime. Subsequently, there must be more problems on the road to arms control in space and a neorealist approach to international politics helps us to discover another one of them. Neorealists whose explanations of international relations resort to *power* as the central variable agree with neoliberals that cheating is a central problem of cooperation under anarchy. However, the problem of cheating is not the only obstacle to international cooperation that they identify. There is also the problem of the distribution of gains from cooperation (Krasner 1991; 1993). The question is not how can we ensure cooperation, but what form should the cooperation take. These distributional problems make the outlook for cooperation more grim and, according to neorealists, the situation is aggravated by the disposition of states to be primarily concerned not with absolute but with relative gains (Grieco 1990; Grieco 1988; Waltz 1979). This means that states are indeed concerned about their gains from cooperation, however, they also worry that other states might gain more from cooperation than they do. Why should states worry about relative losses when they still have absolute gains? The neorealist answer is simple. In a world characterized by anarchy, where each state is looking to secure its survival, it makes sense not to allow other states to gain more, since these gains increase their power. Logically, this means that a state's own power-position shrinks and this means a loss of security (Grieco 1988). Consequently, cooperation should only be expected if it offers balanced gains for all parties.

Now let us apply these thoughts to the case of arms control in space. Can it offer an equal distribution of gains among major space-faring nations? The key to an equal distribution of gains in cases of preventive arms control does not necessarily lie in the equal distribution of overall power between states, but rather in respective levels of technological development. The gains from banning a certain weapon technology are not distributed equally between two states if one state is technologically advanced and therefore capable of developing such technology and the other state is not. A neorealist would only expect preventive arms control if those states that should conclude the agreement are roughly at the same level of technological capability with regard to the weapon technology that is to be controlled. If we look at the major competitors of our case, the United States on the one hand and China and Russia on the other hand, a look at some rough numbers helps to draw a clear picture. I take the space-related expenditures of those states as a proxy for technological advancement in the field of space-flight. The more one state spends on space, the better its technological base for activities in space. According to Pagkratis (2010: 18), the total institutional spending on space, i.e. the sum of the space budgets of all space-faring nations, was estimated to be approximately $67.8 billion in 2009, representing an increase of 9% compared to 2008. 46.9% of this amount ($31.8 billion) is defense expenditures. Out of these defense-related funds, $28.7 billion were spent by the United States. In other words: in 2009, 90% of the worldwide spending on military space programs came from the U.S. However, it makes more sense to also add civilian spending to the indicator since most technologies that are developed for space are inherently dual-use. For example, key technologies of space-flight such as rocket technology, docking capability, or tracking capacity are essential parts of a weapon system that attacks satellites from the ground. The picture does not change very much if we add the civilian expenditures of governments, though. Of the total global institutional space spending, the U.S. space budget made up 72% (in absolute numbers $48.8 billion). The next largest space budget is the budget of the European Space Agency (ESA) that reaches only $4.8 billion. The next largest space budgets of single states are those of Japan ($3.0 billion), Russia ($2.8 billion), France ($2.8 billion), China ($2.2 billion), and Germany ($1.4 billion) (Pagkratis 2010: 18). Although some caution with regard to absolute numbers is appropriate,[38] it is striking how far ahead the U.S. is in terms of money spent on space technology. Even if taken together, Russia and China spend only about 10% of the money on space that the U.S. does. With these numbers in mind, it seems fair to conclude that "[…] the United States is unequivocally ahead of all other countries in space technology" (Johnson-Freese 2007: 230). It seems therefore plausible that it does not have a lot to gain from arms control in space and, hence, rejects all proposals that point in that direction.

However, looking at the spending on space as a proxy for the technological capacity with regard to space is not enough to answer the question on the equal distribution of gains from a space weapon ban. Space weapons are a means to attack objects in space; basically, this means satellites. Consequently, we must determine to what extent states are dependent upon their space assets in order to find out who benefits from the protection of these assets that a verifiable ban on space weapons would bring. In order to answer this question, I take a look at the relative numbers of satellites in orbit.[39] Altogether, there are currently 958 operating satellites in orbit. 441 of those satellites are owned by the U.S., 99 by Russia, and 67 by China. Keeping in mind the large difference in the governments' space budgets, these numbers do not come as a surprise and underline the importance of space to the U.S. Looking at the military satellites of these states, those satellites that are used for reconnaissance, early warning, military communication, and military navigation reveals that the U.S. has 113 dedicated military satellites compared with 65 Russian and 14 Chinese military satellites.[40] Again, we see a clear imbalance between the U.S. and the other two countries. On the basis of these data, the U.S. turns out to be the state in which the military is most dependent on its satellite infrastructure. This dependence of the U.S. military on space, which is widely recognized in the literature, results from the transformation of war-fighting in the last two decades. Communication, navigation, and reconnaissance via satellites have become indispensable for modern warfare. The wars in

38 Comparisons of absolute numbers between countries where economic factors such as prices or wage levels differ significantly can create a distorted picture.

39 The following information is based upon data from the Satellite Database of the Union of Concerned Scientists (UCS) which includes satellites launched through the first of November 2010, available at: http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/ucs-satellite-database.html (9.11.2010).

40 These numbers contain all dedicated military satellites of these countries known to the UCS Satellite Database, including those with mixed users (e.g. commercial satellites whose images are also used by the military).

Afghanistan 2001 and Iraq 2003 have shown that space components are key assets to U.S. forces (Neuneck/Rothkirch 2006: 11). In the Gulf War in 1991, approximately three per cent of the munitions dropped by the U.S. forces were precision-guided, using GPS satellites for guidance. In the Kosovo War in 1999, this number had increased to 33 per cent and in the Afghanistan War in 2001 to 60 per cent. During Operation Iraqi Freedom in 2003, 6,000 of these so called precision-guided munitions were dropped (Hilborne 2007: 178). According to Air Force sources, 68 percent of the munitions used during Operation Iraqi Freedom were precision-guided (Johnson-Freese 2007: 19). The development in the case of military communication satellites is similar. The US campaign in Afghanistan in 2001 used four times the satellite bandwidth of the campaign in Kosovo, which itself used ten times that of the Gulf War in 1991 (Hilborne 2007: 178). Johnson-Freese (2007, 91) concludes on the dependence of the United States on force enhancement through space:

> "At this point, the United States both has the highest capabilities and is the most dependent on those capabilities."

What does this mean in terms of an analysis of cooperation problems? Considering only the first part leads to a rather grim prospect for arms control in space, since the U.S. would not gain much from a ban on technologies where it clearly has the lead. States like Russia and especially China should be expected to seek such a ban, as it would be an instrument to keep the strategic balance more even than in the case of unrestricted development of the technology of space weapons (Handberg 2007: 157; Hansel 2010: 97). This is what happened in the Conference on Disarmament: Russia and China suggested a space weapons ban but the U.S. did not engage in any negotiations. However, the situation becomes more complex if we take the second fact into account, namely that the U.S. is the country that is most dependent upon space. It would be reasonable for such a country to seek to protect its space assets by means of a ban on space weapons. At the same time, it is the dependence of the U.S. on its space infrastructure for its military operations that provides countries such as China the option of using space as a medium for asymmetric strategies. China is increasingly becoming aware of this dependence and the possibility to exploit it by taking down U.S. military spacecraft (Handberg 2007: 158). This explains why the treaty proposed by China and Russia would ban the deployment of weapons in space but not on earth; because these are the weapons that China hopes to have the technological capacity to develop. With this in mind, it is understandable that the U.S. did not agree with the Russian-Chinese proposal. Why should it agree to a proposal that puts limits on the further development of technologies in which it is leading, when at the same time its major competitors would not face similar restrictions?

The combination of the worries of both sides – the U.S. would like to restrict debris-creating tests of ground-based ASATs and China and Russia would like to restrict the development of space-based weapons – creates space for cooperation. In other words, issue-linkage could provide for more balanced gains. An earlier attempt by the Chinese included a ban on ground-based ASATs. This could have been the basis for an agreement that would have included a ban on testing ground-based missiles against targets in space; an agreement that would have outlawed the Chinese ASAT test in 2007 and, one could argue, would have been in the interest of the United States. In return, the U.S. would relinquish the option to develop highly sophisticated space weapons such as space-based lasers or interceptors. Since missile defense technology can also be used against satellites, any agreement on arms control in space must take into account the importance the U.S. ascribes to missile defense. For arms control in space to become possible, then, either the U.S. must change its position on missile defense (Hansel 2010: 97-98) (which does not seem very likely), or an agreement on arms control in space must be carefully tailored not to restrict the missile defense plans of the U.S. (and other countries). This is possible, if an arms control agreement bans the testing and deployment of space weapons in space and on earth with the exception of permitting the testing of interceptors in low-Earth orbit (see for example the proposal made by Moltz 2002). This might not be the best solution from the perspective of space security since missile defense technologies have an inherent ASAT capability. However, it seems that the U.S. is committed to missile defense and would not accept any proposal that restricts its development.

An arms control agreement that bans the development of both rather simple and highly sophisticated space weapons, could be a compromise which is acceptable to moderates on both sides of the debate within the United States as well as those in other relevant countries such as China and Russia. In particular, the change of the U.S. administration from Bush Jr. to Obama has created a window of opportunity because this new administration is – at least in principle – open to the idea of arms control. One problem of this suggestion (and Moltz notes that) is the remaining residual ASAT capability of the permitted missile defense technology, but it does outlaw quite a lot of destabilizing space weapon technologies and could be a starting point for the discussion over a solution that offers balanced gains for all parties.

4.3 Arms control in space and knowledge

Similar as with the problem pointed out by the interest-based approach, the identification of the relative gains problem is also insufficient to explain why we have not seen more progress in the negotiations on arms control in space. If there is a chance to realize absolute gains that are balanced, and if the fear of cheating could be reduced by means of verification, it is puzzling that we have seen so little progress in the negotiations on arms control in space; in fact, that we have seen no serious negotiations on arms control in space at all. What is missing then? I argue in this chapter that it is a process in which all sides learn that they do not gain an advantage by unilateral action. As long as there is no consensual knowledge on that, cooperation seems to be highly unlikely. Both sides focus on the military advantages that space weapons could bring and neglect their negative consequences (for the military and the civilian use of space) that stem from the inherent interdependence of the situation. In his study on "nuclear learning" between the United States and Soviet Union during the Cold War, Joseph Nye (1987) finds that states can redefine their interests as a result of a learning process. In such a case, new knowledge leads to a change of prior beliefs and to a redefinition of national interests.

> "Awareness of newly understood causes of unwanted effects often results in the adoption of different, and more effective, means to attain one's ends" (Nye 1987: 378).

Nye observes such an alteration of prior beliefs in the case of "nuclear learning" between the superpowers. New information about the destructiveness of nuclear weapons led to consensual knowledge that a nuclear war could never be won and consequently, the avoidance of nuclear war – and not the attainment of nuclear superiority – became the top priority of the security policy of both powers. One consequence of this learning process was the creation of the bilateral arms control regime with SALT and the ABM treaty as its outcome.

Similar learning has not occurred in the case of space weapons, although there are quite good arguments against the military utility of space weapons. No country can expect to have a monopoly on space weapons because it is not necessary for states that want to attack objects in space to have the same level of technology as the U.S. Every space-faring nation has the inherent capability to develop ASATs. Even countries that only have short- or medium-range missiles can reach satellites in LEO. If they do not have the capacity to develop homing interceptors to hit the target directly, they could release clouds of pellets in the path of the target satellite. Such asymmetric means make it possible to counter sophisticated space weapons such as space-based laser weapons.[41] Consequently, the argument can be made that it is very unlikely for any state to be able to control space, and that the debris resulting from an arms race in space, not to mention a full-scale future space war, would negatively affect the usability of space for everybody. This knowledge of the problems associated with space weapons and the negative impact of space war on the usability of space is far from being consensual, however. In particular within the U.S. Air Force and among conservative think tanks, the ideas of space superiority and space control prevail. Consequently, a respective reshaping of national interests – from attaining space superiority to the avoidance of space war – has not developed yet. U.S. space policy might vary from administration to administration; putting the avoidance of war in space at the top of the priorities, however, has not occurred. Quite to the contrary, under the Bush administration, the U.S. was even pursuing space superiority actively. And whereas China and Russia voice support for a treaty on arms control in space, their latest proposal indicates that they want to preserve the option to develop ground-based ASAT weapons which would give them the option to put U.S. satellites at risk (see chapter 2.2). As long as there is no consensual knowledge on the dangers of a war in space, little progress on arms control should be expected.

If a lack of consensual knowledge is the problem, the question is how does consensual knowledge in the field of weapons and arms control develop? Some authors argue that epistemic communities play a crucial role in the process of developing consensual knowledge (Haas 1997b). An epistemic community is "a network of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge within that domain or issue-area" (Haas 1997a: 3). Epistemic communities have a shared set of normative and principled beliefs; shared causal beliefs; shared notions of validity; and a common policy enterprise (Haas 1997a: 3). It is the provision of knowledge that constitutes the power of epistemic communities. They point

41 This line of argument is based on the technical information given in Wright/Grego/Gronlund (2005).

out the alternatives decision-makers have and they can, on the basis of their causal or normative understanding, discount and sometimes even exclude certain alternatives. One can conceive of epistemic communities as "norm entrepreneurs" that by means of knowledge-provision promote certain norms.[42] Adler (1997) has shown that American scientists in the 1960s who were concerned about the threat of a nuclear war between the United States and the Soviet Union played a key role in bringing about superpower arms control by providing knowledge on the impossibility of a technical solution, i.e. unilateral armament, to the threat of mutual assured destruction, pointing out that nobody can win a nuclear war. These scientists managed to institutionalize their knowledge on a transnational level by means of international conferences and scientific forums.[43] Such institutions helped to establish contacts with Soviet scientists who learned about the ideas of their American colleagues and "translated" them to the Soviet leadership. This in turn facilitated a shared understanding between U.S. and Soviet officials "about why and how they should cooperate, how to start negotiations, what to include in the agenda, and how to conceptualize norms and rules for particular tasks" (Adler 1997: 144). With this study, Adler provides an account of the micro-processes for "nuclear learning" that Nye has identified as crucial for the establishment superpower arms control.

What are the chances that a similar development could take place in the case of space weapons? It is fair to say that the basis for such an epistemic community is present. In the U.S. there exist a number of scientists with considerable expertise on the subject who are critical towards the development of space weapons. They put forward many good arguments against the utility of space weapons and point to the dangers of these weapons.[44] These scientists could form the nucleus of an epistemic community that acts as a "norm entrepreneur" for arms control in space and counters the arguments of the proponents of space weapons. However, it is not enough to come up with good arguments and convincing evidence alone. Bureaucratic politics play a role, too. In order to make their knowledge influential upon the thinking of decision-makers, epistemic communities must institutionalize their scientific advice (Haas 1997a). This is supported by the finding of Adler (1997) that many prominent members of the arms control community who played a leading role as promoters of the idea of nuclear arms control and who established the contacts with their Soviet colleagues were hired into key positions in the Kennedy administration. The institutionalization of the exchange between the scientists from the U.S. and the Soviet Union was also very important in this regard (Kubbig 2004: 164-220). The establishment of an institutionalized transnational

42 In her review of strategies and tactics for multilateral arms control negotiations, Johnson (2006) makes an explicit reference to civil society actors such as NGOs or epistemic communities as norm entrepreneurs. On the concept of the norm entrepreneur in general, see Finnemore/Sikkink (1998); Florini (1996); Nadelmann (1990).

43 For a detailed account of this process, see Kubbig (2004: 164-220).

44 There is the "Reconsidering the Rules of Space Project" of the American Academy of Arts & Sciences, and the work done by the Union of Concerned Scientists on space weapons. See the respective homepages that provide access to most of their publications on this issue: http://www.amacad.org/projects/space.aspx and www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/ (30.7.2010).

dialogue among scientists from the major space-faring nations on the consequences of an arms race in space would be an important step to start a similar learning process as in the case of "nuclear learning" during the Cold War. Such an exchange could take the form of regular meetings of scientists from the major space-faring countries. The common publication of a report that contains the agreed-upon findings of the group could also be considered. If the European Union wants to strengthen its Code of Conduct initiative and even to go beyond it, the initiation of a series of expert-conferences on the dangers of war in space would be a reasonable means to do so.

5. Conclusion

The argument of this paper can be divided into three parts. In the first part (chapter 2) I took a look at where we are in the debate about the weaponization of space. There are various technologies that could be used for the development of weapons that can either act from *earth to space*, from *space to space*, or from *space to earth*. These technologies are not fully developed but all major space-faring nations have the capability to develop at least basic ASAT technology and the United States has even considered highly sophisticated weapons such a space-based lasers or interceptors. If one state should pass the threshold and develop space weapons, it is highly likely that others will follow. This could lead to an arms race in space. Such an arms race in space would have negative consequences for space safety and for the security of all space-faring nations. No state can be sure to develop such space weapons that would deter others to attack its space systems. Quite to the contrary, the development of basic ASAT technology means that other countries' space assets are at risk and this could open the door to threats, miscalculation, and – in the worst case – a war in space. Such an exchange of violence in space would strongly restrain the usability of space and it could escalate to war on earth. But even below the threshold of a space war, space debris resulting from (some) space weapon testing, could severely affect space safety. In addition, the development of space weapon technology costs a lot of money. Hence, an arms race in space should be avoided.

How could this be achieved? In the second part of this report (chapter 3) I argue that the establishment of an international regime of arms control in space is the best strategy to do so. There have been various proposals for arms control in space made by states at the Conference on Disarmament, most recently by Russia and China. Until now, all these attempts have failed and many consider the idea of "rules of the road" as the only realistic approach. The EU, for example, proposed a Code of Conduct for Outer Space Activities. I agree that such rules would be an important and good step towards more security in space because they define responsible and irresponsible behavior – for example the interference with satellites – in space. However, such rules would not ban the development of certain technologies and are therefore not sufficient to avoid an arms race in space. A code of conduct for space as it is proposed by the EU is reasonable but it should be supplemented by a long-term strategy to establish arms control in space.

In order to develop such a strategy, in the third part of this report, the problems that have inhibited arms control in space so far are analyzed on the basis of theoretical considerations on the establishment of international regimes (chapter 4). A first regime-theoretical approach that focuses on the interests of states and the collective action problems that result from interdependence identifies states' fear of cheating as a central obstacle to arms control in space. This fear is reflected in the American concerns for effective verification. Indeed, drawing up mechanisms for verification must be part of any arms control agreement for space. This is possible, though. Although not every action that could lead to the development of space weapons can be verified, testing space weapons under real conditions can. Since space weapons cannot be developed overnight, this allows states to make use of a strategy of reciprocity, a kind of space weapons testing tit-for-tat. Neorealists, however, correctly point out that cheating is not the only problem on the way to international cooperation and identify the distributions of the gains from cooperation as a central problem. Doubtless, tough negotiations would lie between the start of negotiations and a successful agreement on arms control in space that provides balanced gains. However, such an agreement is possible. A ban of the use, testing or deployment of weapons in regions of space above 500 miles as proposed by Moltz (2002) provides for a compromise between the United States who chiefly would benefit from a ban on ground-based ASATs and on the other side Russia and China who seek mainly to restrict the placement of weapons in orbit. The core elements of this proposal include:

- No use, testing or deployment of weapons or interceptors of any sort in regions of space above 500 miles;
- Permitted testing of ground-based, sea-based, and air-based interceptors in low-Earth orbit (60-500 miles) against ballistic missiles passing through space;
- No stationing of weapons of any sort in low-Earth orbit;
- No testing or use of lasers from ground-, sea-, or air-based platforms against any space-based, orbital objects;
- No testing or use of other ground-, sea-, or air-based weapons against satellites or other space-based objects.

Given that arms control in space is identified by this report as both, useful and achievable, this report recommends the EU to think beyond its Code of Conduct initiative and to develop a proposal for an international regime for arms control in space. However, as both cooperation problems – the fear of cheating and the unequal distribution of gains – can be solved, the fact that arms control in space seems to be so far away hints at an additional problem that must be solved before the other two problems can be tackled. An approach that focuses on the role of knowledge provides helpful insights here. The problem is that there is no consensual knowledge on the negative consequences of unilateral action in space and especially on the danger of a war in space. In the same way as nuclear arms control between the superpowers during the Cold War was only possible after the establishment of shared knowledge on the impossibility of increasing their security by means of unilateral armament, arms control in space should only be expected after the central actors have learned that unilateral action in space does not increase, but decrease their security.

As we have also seen from the case of nuclear arms control during the Cold War, the establishment of a transnational epistemic community can play an important role in such a learning process because it establishes shared standards of judgment and acts as a transmission-belt of knowledge between political systems. The establishment of a transnational dialogue among scientists from the major space-faring nations on the consequences of war in space could play an important role with regard to a learning process that aims at the establishment of consensual knowledge about why and how states should cooperate on arms control in space. Such a process might well find the support of another group of non-state actors in space. Private companies that make a lot of money from space application and consequently are interested in space safety are likely to play an increasing role in future scenarios of space flight. When these new actors become more influential, they might be powerful proponents of restrictions on activities and technologies that might interfere with the commercial use of space (Moltz 2008, 328). An alliance of these groups of non-state actors could be the driving force behind a learning process on space cooperation. If states shared an understanding of the futility of unilateral armament in space, the "political will" for cooperation should be present, and then the other problems could be tackled. In order to facilitate such a process of knowledge-building, the EU should make use of the window of opportunity created by the general openness of the current U.S. administration towards international cooperation and initiate a series of conferences among scientists from the major space-faring nations on the dangers of war in space. The build-up of such knowledge will take time but it could provide the ground for a space-related success story that does not stem from the newest technical advancements but from political prudence.

Abbreviations

ABM	Anti-Ballistic-Missile
ASAT	Anti-Satellite
CD	Conference on Disarmament
COC	Draft Code of Conduct For Outer Space Activities
ESA	European Space Agency
FMCT	Fissile Material Cut-off Treaty
GMD	Global Missile Defense
GPALS	Global Protection Against Limited Strikes
GPS	Global Positioning System
HEL	High Energy Laser
IAA	International Academy of Astronautics
ICBMs	Intercontinental Ballistic Missiles
LEO	Low Earth Orbit
MIRACLE	Mid-Infrared Advanced Chemical Laser
OST	Outer Space Treaty
PAROS	Prevention of an Arms Race in Outer Space
PPWT	Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects
SDI	Strategic Defense Initiative
SSN	Space Surveillance Network
TCMBs	Transparency- and Confidence-Building Measures
UCS	Union of Concerned Scientists
UN	United Nations
UNCOPUOS	United Nations Committee on the Peaceful Uses of Outer Space

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